International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 9, Issue 1, Feb 2019, 113-118

A RAPID PROTOTYPING OF COMPOSITE MATERIALS

J. MANOJ KUMAR & P. NAGABHARAM

Assistant Professor, Department of Mechanical Engineering,

S R Engineering College, Warangal Telangana, India

ABSTRACT

The new materials are most essentially required for divergent application in the field of aerospace industry. The conventional materials fail to satisfy the complex needs of the new applications. The materials should be of low weight with high strength. The materials should be corrosive resistant and non-reactive to the environment. Such requirements are contradicting with each other. So the new type of materials named as composites came into existence for the last three decades. The manufacturing of these composites is in a different way to conventional materials, like steel. The composite materials consist of two or three constituents. The important constituents are fiber, resin and the remaining are filler material. For making a huge structure, the composites are made by hand layout process. But for the small products like automotive parts, interior decorative manufacturing can be done with machines. In this paper the applications of rapid prototyping to prepare the composite materials are discussed. Surely, the rapid prototyping will decrease the cost of manufacturing, reduce the time, reduce the wastage of materials as the scrap.

KEYWORDS: Rapid Prototyping, Composite Materials, Manufacturing of Composites, Stereo Lithograph & Additive Manufacturing

Received: Sep 07, 2018; **Accepted:** Sep 27, 2018; **Published:** Dec 27, 2018; **Paper Id.:** IJMPERDFEB201912

Original Article

1. INTRODUCTION

The world's economy is ruled by the conventional fuels like diesel and petrol. The aerospace industry is affected by the cost of aviation fuel; a special type of petroleum based fuel. The surviving of the aerospace industry depends on the cost the fuel. As the fuel cost increases, the passengers are required to pay more money. To reduce the cost, one of the possibilities is to reduce the weight. The weight of passenger's luggage is one aspect and then reducing the weight of the craft, i.e. aeroplane. To reduce the weight of the craft, its accessories and other components must be made with the low weight material without compromising on the strength of the component. As the life of passengers is the most important aspect, the plane should not fail. 'Composite material' can satisfy the different requirements. The rapid prototyping helps the manufacturing of composites in a better and an efficient way.

2. LITERATURE REVIEW

With composite material the designer has the freedom to choose the material, laminate and manufacturing method to suit the design requirements. This means a more optimized structure can be designed [1]. Rapid Prototyping (RP) of physical parts or otherwise known as 'solid free from manufacturing' or 'desktop manufacturing' or 'layer manufacturing technology', which represents the new phase in the evolution of prototyping [2]. University of Delaware Center for Composite Materials (UD-CCM) has developed a rapid fabrication of polymer matrix composites by a technique called automated tow placement or ATP [3]. Marc Scholz

et al successfully fabricated the glass – epoxy composite by using ultrasonic energy to align the fibers in a predefined manner in the epoxy resin [4]. Jasper Cerneels addressed the need of modernization of composite fabrication. The conventional methods are not enough to manufacture the composite laminates in bulk. Industry reports indicate that RP or Additive Manufacturing (AM) is a resilient technology and one that has yet to reach its full promise, particularly in the field of composites. Rapid Proto Typing RPT is defined as a process of rapidly creating a system or part representation before final release or commercialization [5]. The rapid prototyping makes the visualization of the entire fabrication process of a component. The visual aids are the home ground of the RPT process and the low cost 3D printing techniques can make the prototyped model easily [6]. The rapid prototyping can be achieved easily by the use of stereo lithography (SL) technique to make a model. The complex three dimensional shapes can be made accurately with SL [7]. 3D printed parts are accurately made of 3D printing. One of the defects is that many voids can be formed while 3D printing. To reduce or eliminate the voids, open faced moulds and vacuum bag moulds can be used for 3 D printing [8]. Fused Deposition Modelling (FDM) rapid prototyping systems can fabricate parts in a range of materials including elastomers, ABS (acrylonitrile butadienestyrene), and investment casting wax [9].

3. COMPOSITE MATERIALS

The meaning of composite materials is that, it is composed of two or more constituents. The composites, especially fiber reinforced composites (FRC) are generally used to carry more loads. The FRC is made of fiber and resin. The fiber is the reinforcing agent and the resin is a matrix which is a binding agent. The fillers may be used to reduce the cost of fiber and resin. The load will be taken by fibers and the fibers are bound by the resins. The conventional fibers are carbon, glass, boron etc. The conventional resins are polyester, epoxy etc. The composites used in aerospace industry are generally called advanced composites. The advanced composites will reduce the weight of the structure up to 70 % without compromising the quality and strength of the structure. The advanced composites are also used in many applications like sporting goods, artificial satellites, tennis and golf rackets. One of the outstanding advantages of composites is that the more complex shapes can be easily manufactured. The sporting bicycle component, the golf rackets are having complex bending shapes. These shapes can be easily obtained.

4. FABRICATION OF COMPOSITE

The composites are of thermo plastic and thermo set types. The following are the general methods of manufacturing the composites:

- **Hand Layup Process:** It is the simplest, oldest method of fabrication of composites. Semiskilled persons can easily prepare the composite. The low volume products can be made with the hand layup process. Fabrication of boats, ships, automotive parts, dooms of large buildings can be made with a hand layup process.
- **Spray Layup Process:** The spray layup process is similar to the hand layup process. In hand layup process the resin is laid by the hand brush but in the spray layup, the resin is sprayed with the sprayer. The fabrication takes less time in the spray layup method.
- **Bag Molding:** It is similar to hand molding and spray molding process. In this process the fiber and resin is laid in a bag. The curing agent is not added while laying them in the bag. The positions of fibers, resin are kept in a predefined method. When layup is completed the bag is closed. Then curing agent liquid is passed into the bag, so

that it binds the fiber and resin.

- **Resin Transfer Molding:** It is known as RTM. In this, the fiber is kept in a closed container and then pressurized to make it close and air tight. The resin with curing agent is passed through the fibers.

In all these methods the common thing is that the fiber and resin are bound together.

5. RAPID PROTOTYPING

The rapid prototyping is the latest technique, which improves the manufacturing methods. In rapid prototyping, a model is built by adding successive operations. It uses all the latest tools of engineering like computer programming, CAD / CAM, 3D modelling etc. RP techniques are commercially available, that include, stereo lithography (SLA), Selective Laser Sintering (SLS), Laminated Object Manufacturing (LOM), Fused Deposition Modelling (FDM), Solid Ground Curing (SGC) and Ink Jet printing techniques.

6. RAPID PROTOTYPING (R P T) FOR FABRICATION OF COMPOSITE MATERIALS

The 3D model of the composite material which is to be fabricated is configured with computer software. The interrelation between the 3D model and the operation of the machines is obtained by the interconnection of machinery with CAM software. The input is the prototype model. The output is a program that is entered into the control unit of certain machines, based on which the machine produces the corresponding part. To further the integration of the CAD/CAM system with various machines, various knowledge bases, information systems, expert systems is done with the Computer Integrated Manufacturing CIM.

Assumptions in RPT

- It depends on the CAD software and it is assumed that CAD software suitably builds a model with fibre and resin. There is no gap between two fibres or fibre and resin.
- Complex counters are machined with the software tools. Similar machining is assumed with the tools practically while fabricating the composite.
- The auto LISP is used to make complex shapes, with accurate coordinates, but while machining the composites practically, the coordinates are not accurately maintained.
- The fabrication of the composites is generally a wet process, but the computer software assumes it as the dry process. The viscosity of the resin plays an important role in fabrication. While machining the fluid slips, and slides many other deformations takes place, these defects will not be addressed in the computer modelling.
- The computer assumes the uniform distribution of temperature in the model, but in the fabrication unit the temperature of the system is controlled by many factors. The conduction of the moulds, tools play an important role.

The basic process of RPT is given in the layout figure 1.

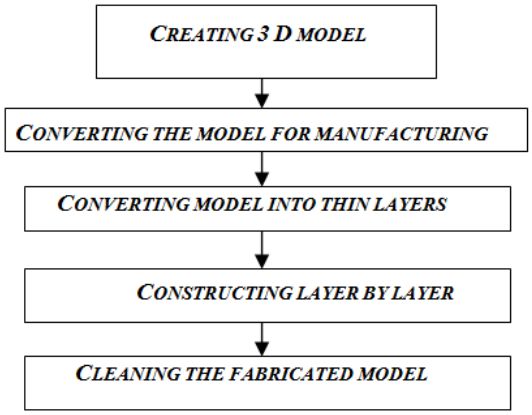

Figure 1: The RPT Process Step by Step

7. CONCLUSIONS

The additive manufacturing technology has received a vast amount of attention over the last decade. The RPT can easily identify the critical process parameters for the composite material fabrication system. The composite system is tested for fibre pull out strength and load transfer capacity of the fibres easily in the programming. It has been proved that the extrusion-based additive manufacturing techniques have a positive effect on the fiber alignment in the resulting parts. The main weakness of extrusion-based polymer parts is the interlayer bonding strength between adjacent layers.

REFERENCES

1. *Menaga Mohan "The advantages of composite material in marine renewable energy structures" Paper presented at RINA Marine Renewable Energy Conference 2008*
2. *Novakova - Marcincinova, Novak – Marcincin "Applications of rapid prototyping fused deposition modeling materials" Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382*
3. *R. Vaidyanathan, C. Green, T. Phillips and R. Cipriani. "Rapid Prototyping of Continuous Fiber Reinforced Ceramic Matrix Composites" **SBIR** program funded by NASA **Marshall** Space Flight **Center** under contract numbers NAS8-00084 and NAS8-00192*
4. *Malarvizhi, G. (2015). Development of herbal finished baby diapers with bamboo fiber. International Journal of Humanities, Arts, Medicine and Sciences, 3(2), 41-46.*
5. *P. Nagabharam "Fabrication, Characterization And Testing Of Aluminum Based Composite Material" `International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 11, November 2017, pp. 494–499*
6. *P. Nagabharam*1, L. Radhakrishna*2, Dheeraj Joshi*3 "Mechanical Properties Of Aluminum Based Composite Materials" International Journal of Engineering Research | Vol.3., Issue.6., 2015 (Nov.-Dec.,) | pp 242-245*
7. *J. Manoj kumar and N. Gopikrishna " Comparative Studies On Mechanical Characteristics Of Granulated Blast Furnace Slag And Flyash Reinforced Aluminium Composites" International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 11, November 2017, pp. 277 – 284*
8. *KM, A. F., & Varghese, S. (2014). Behavioural Study of Steel Fiber And Polypropylene Fiber Reinforced Concrete.*
9. *Butterfield, Lena R., "Developing and Characterizing a Rapid Prototyping Stereo-Lithography Machine to Produce Interpenetrating Polymer Network Systems" (2013). Mechanical (and Materials) Engineering – Dissertations, Theses, and*

Student Research. Paper 52.http://digitalcommons.unl.edu/mechengdiss/52

10. *Nadya Peek "Rapid Prototyping of Green Composites" thesis Submitted to the Program* ***in*** *Media Arts and Sciences, School of Architecture and Planning, in partial fulfilment of the requirements for the degree of Master of Science at the Massachusetts Institute Of Technology September 2010 @Massachusetts Institute of Technology 2010.*
11. *P. Dudek "FDM 3d printing technology in manufacturing composite elements" Archives of metallurgy and materials ,Volume 58 2013 Issue 4DOI: 10.2478/amm-2013-0186*
12. *Lyashenko, V. Y. A. C. H. E. S. L. A. V., Ahmad, M. A., Kobylin, O., & Khan, A. (2017). Study of Composite Materials for the Engineering using Wavelet Analysis and Image Processing Technology. International Journal of Mechanical and Production Engineering Research and Development, 7(6), 445-452.*
13. *D. Srikanth rao, N. Gopi Krishna, J. Manoj kumar "Evaluation of Mode-I Fracture toughness for Composite laminate-epoxy-glass fiber" Research Journal of Engineering and Technology. 9(1): January- March, 2018*